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# ASA association Connections

THE AUSTRALASIAN SLAG ASSOCIATION NEWSLETTER



## Editorial comment

**WHEN** metals are separated from their ores by some often spectacular but controlled pyrometallurgical process, two primary products are formed. One is molten metal, generally the object of the process and the other is molten slag that is able to be processed into a range of materials with application to the construction, industrial processing and agriculture industries.

In the 11th year of this association operation it is useful to reflect on the development of the slag industry, particularly in Australia. The "industry" has really been around for a long time. In Roman times, slag materials were used in road making, some evidence of which remains to this day. Cannon balls have been cast from slag and in the 1800's, slag cement was used in the construction of the French underground rail tunnels.

Australia, a country with seemingly unlimited resources of rock and land was a comparatively late starter in the development of the slag industry. Although ore refining processes have been operating in Australia since the 1800's, development of the slag industry really began in the 1960's. Granulation of Iron Blast Furnace slag has given rise to the development of the slag cement industry, whilst the granulation of Copper Slag has provided opportunities for use in abrasive blast cleaning. Each of the uses developed for slag replaces some alternate material that would have been mined or quarried from of this nations finite stock of good quarry materials and minerals.

The persistence and hard work of a comparatively small band of researchers, academics, engineers, marketers industrialists technologists and managers has been the driving force for the development of new slag products and markets over a period of more than 40 years. This issue of Connections acknowledges the efforts of Bruce Fenton Technical Sales Manager Roads for Australian Steel Mill Services. Foundation ASA Executive Officer Doug Prosser a staunch advocate for the use of slag products, retired in June with over 10 years service (more of this in next issue). These are typical of the committed people who have guided the Australian slag industry to its current stage of development.

**EDITORIAL**

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## The Sydney Harbour Tunnel–durability a key factor

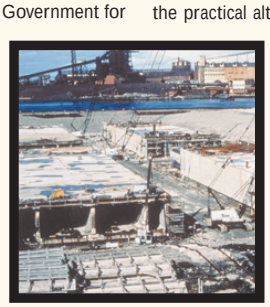
**AMIDST** the euphoria of the Olympics 2000 and its associated massive construction program, it's easy to overlook some of the remarkable engineering achievements of the recent past such as the Sydney Harbour Tunnel.

Today as we drive through we tend not to think about this remarkable structure, but only watch our speedo with the certain knowledge of the speed cameras' presence.

However the Tunnel proposal as recently as a decade ago was looked upon with much concern by some in the engineering fraternity. Although immersed tube concrete structures were relatively common in cities such as Hong Kong, this project was proposed for under our Sydney Harbour and somehow this was different.

It's surprising that something that caused so much concern in the late 1980's is now accepted so completely in the late 1990's. It opened to traffic on 31 August 1992, a date that was set by the contractor Transfield-Kumagai Joint Venture well before the construction commencement date of January 1988.

The concept of the project was impressively simple. Tenders were called by the Government for a second vehicle crossing of the Harbour to and from North Sydney, which resulted in a variety of bridge designs, all of which had a common self destructing component. That was because extensive resumptions of properties – most containing homes and commercial premises were required to provide road access on both sides of the harbour.



The Transfield-Kumagai proposal was an exquisite example of lateral thinking. It identified the bottleneck as the existing beloved Harbour Bridge with its eight traffic lanes. The constriction was created because there were twelve lanes on the North Shore and twelve lane on the City side adjoining the bridge having to merge into eight. We all know the hassles of the common road situation of two lanes leading into one – very few drivers are prepared to readily allow merging.

The Transfield-Kumagai proposal simply offered the practical alternative of adding four more lanes to the bridge, which gave twelve uninterrupted vehicular access lanes from the city to the North Shore. The punch was that the lanes were not hung off the bridge as some had suggested but laid down beside it - but under water. Clever design meant that no resumption of properties was required which was a major positive factor in the tender evaluation process. This of course was only possible by using a precast tunnel across the floor of the harbour instead of the conventional bored tunnel which would have to be much deeper underground creating unacceptable grades to keep the new roadway within the existing publicly owned road system.

Transfield-Kumagai had retained MacDonald Wagner (now Connell Wagner) to advise in

*continued page two*

**It is obvious that the cement used in a structure such as this will play a major role in achieving low chloride penetration, low heat of hydration and minimal drying shrinkage cracking.**

*from cover story*

structural design was in turn commissioned Freeman Fox (now Acer Consultants) to assist. The following extracts in italics are taken from a paper prepared jointly by Dr Lewis Gomes of Connell Wagner and Martin Morris of Acer Consultants. Their paper was presented at a conference "Concrete For The Nineties" held in Leura, NSW 3-5 September 1990. The overwhelming concern facing the designers was that of durability with the then Department of Main Roads nominating that a minimum life span of 100 years was required of the structure. The problem of a submerged tube section is that it is subject to the "hollow leg" syndrome, viz:

## SERVICEABILITY DESIGN CONSIDERATIONS

### *DURABILITY*

*The chemical process of chloride and sulphate attack on the concrete matrix and the electro-chemical process of reinforcement corrosion has been well described by others (Eglington 1987). However, some aspects of durability are of particular relevance to immersed tube construction and are briefly reviewed below.*

*In a seawater environment, sulphate attack is diminished by the presence of chloride ions. This is because the expansive sulpho-aluminate salts (ettringite) which result from sulphate attack on the tricalcium aluminate (C3A) content are more soluble in chloride solutions enabling them to be leached out prior to disruptive expansion.*

*The more serious concern is chloride penetration which neutralises the natural alkalinity of concrete and renders the reinforcement susceptible to corrosion, and subsequent spalling. The rate of chloride penetration is directly linked to the permeability of the concrete matrix so that durability requires a sound, dense mix. The presence of cracks accelerates the rate of penetration over local areas, and therefore crack control also forms an inherent part of designing for durability.*

*Reinforcement corrosion is dependent on oxygen supply and since in permanently submerged concrete this is dependent on dissolved oxygen and diffusivity through saturated concrete, the process is significantly inhibited relative to reinforced concrete in the splash zone.*

*Nevertheless, concrete exposed to seawater on one side and air on the other, as in an immersed tube, is a special case of the corrosion process. The mechanism was first postulated during the 'Concrete in the Oceans' research program by CIRIA/UEG on offshore gravity structures and applied to hollow legs of oil platforms. The relatively free availability of oxygen at the inside surface enables the inner reinforcement to become highly cathodic and set up galvanic action with the outer layer of reinforcement. The resistance of the electrolyte is reduced by saturation by water and further still by chlorides, so that the true "hollow leg effect" has to be assessed from actual penetration of seawater chlorides into structural concrete.*

*It can be seen that whilst concrete totally immersed in seawater would normally be "low risk", the presence of oxygen within the tube contributes to a greater than normal risk.*

It is obvious that the cement used in a structure such as this will play a major role in achieving low chloride penetration, low heat of hydration and minimal drying shrinkage cracking. With prior knowledge that blended cements gave better performance with these characteristics than Ordinary Portland Cement (OPC) it was decided to further investigate the following blends:

- OPC with pulverised fuel ash (pfa);
- OPC with ground granulated blast furnace slag (ggbfs);
- OPC with pfa and ggbfs (triple blend).

The aggregates used would also play an important role in the concrete particularly with drying shrinkage, which was one of the stringent requirements of the concrete specification for obvious reasons. As the tunnel units were to be cast in Port Kembla, a choice of two economically available aggregates were considered viz South Coast basalt and iron blast furnace slag.

*It was concluded that a high replacement blend of ggbfs or pfa, or a triple blend of both could offer the benefits of:*

- reduced heat of hydration (equal to Type C);
- very high resistance to chloride penetration;
- good sulphate resistance (without increasing chloride ingress);
- acceptable stripping times;
- ready availability.

Further, good quality high density natural aggregates were readily available, but the use of slag as an aggregate might have cost and shrinkage advantages.

Accordingly a series of laboratory trials were set up to test these conclusions quantitatively.

### *CONCLUSIONS*

*The time/temperature plots showed that by using cement replacement methods, it was possible to simulate the approximate level of heat of hydration output from low heat Type C cement. The ACSE/ggbfs (50/50) mix using natural aggregate produced marginally the best result based on these particular tests. An ACSE/ggbfs (35/65) mix would be expected to produce a better result. Accordingly, it was decided to concentrate on ggbfs mixes, particularly with their high resistance to chloride attack, and wide use in Europe for marine structures.*

*In spite of the excellent shrinkage performance of the slag aggregates, no precedent for its use in major marine structures could be found outside Australia. Since the test results also confirmed its density to be about 3% less than equivalent Dunmore basalt mixes, it was reluctantly decided not to pursue the use of slag aggregate.* C

The cement used on the project was the ACSE ground granulated blast furnace slag and the coarse aggregate was basalt from Dunmore Quarry.

It is stressed that extracts quoted are only a relatively minor part of the very comprehensive paper by Gomes and Morris, which contains complete supporting data. The paper is recommended reading for engineers interested in high performance marine structures.

This composite paper was prepared by Doug Prosser, Secretary/Treasurer of the Australasian Slag Association.

# SYDNEY HARBOUR TUNNEL

# New **members**

### Sunstate Cement Ltd

Sunstate was incorporated in 1982. It is an unlisted public company and is jointly owned by Boral Ltd and Adelaide Brighton Ltd.

Sunstate Cement Ltd manufactures and distributes a range of cement and cement blended products throughout South East Queensland and Northern New South Wales. Sunstate distributes cement in bulk and bagged form to customers in a range of industries including Premix concrete, road stabilisation and concrete product manufacturing. Bagged cement is also available through major hardware stores and a number of landscape yards in Queensland.

Manufacturing takes place at Sunstate's Fisherman Islands plant in Brisbane, Queensland. Sunstate has a skilled workforce and a modern, highly automated plant. This ensures that production is safe, clean and efficient and that cement is of a consistent quality.

Sunstate is accredited to ISO 9002 and has a NATA certified laboratory which monitors the quality of all products. Sunstate currently has achieved National Safety Council of Australia's 5 Star status in recognition of its safety performance and systems.

The ASA would like to welcome Sunstate Cement Pty Ltd to the Association. For more information please contact the Sales & Marketing Manager, Mr David Jones, on telephone (07) 3895 1199, or facsimile (07) 3895 1198 - website:http://www.sunstatecement.com.au.

### Port Kembla Copper Pty. Ltd.

Port Kembla Copper Pty. Ltd. (PKC) was founded in 1996 to undertake the acquisition and redevelopment of the copper smelting and refining site at Port Kembla, NSW. The

new operations were officially re-opened in early 2000.

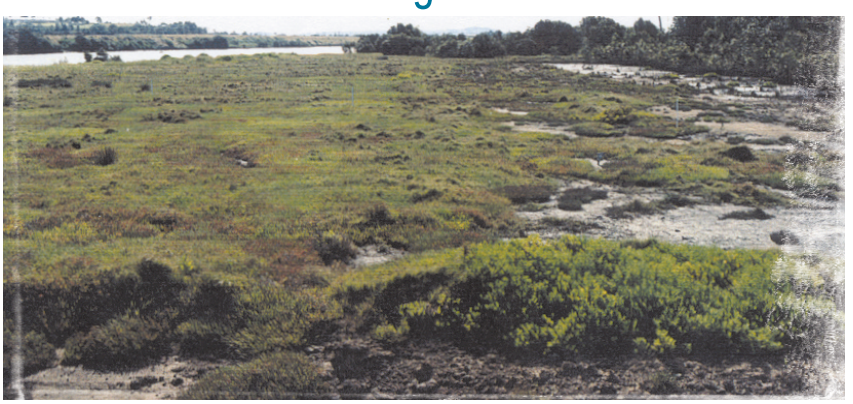
It has undertaken substantial modifications and upgrades to the equipment and buildings at the Port Kembla site. The result is an increased capacity, improved quality and productivity through the application of modern technology, and a substantial improvement in environmental practices and performance.

This unique mix of technologies have been applied by PKC aimed at achieving long term viable output of 120,000 tpa of refined copper cathodes. The plant configuration and controls are also intended to bring about a sustainable and acceptable environmental outcome aimed at achieving WHO emission standards.

Under current planned copper production levels PKC will produce approximately 200,000 tpa of granulated copper slag. The ASA and its members welcome PKC to the Association, we look forward to assisting PKC in developing viable commercial uses for the use of this valuable mineral resource.

If you would like more information please contact the Mr. Simon Hay, Engineering and Technical Services Manager, on telephone (02) 4275 0243, or facsimile (02) 4276 1155 - http://www.pkc.com.au

# **Healthy report** stems from regenerated waste site



**Landmark** research has shown wetlands regenerated on industrial waste at Kooragang Island are functioning as well as their natural counterparts.

The Newcastle-based research has drawn international interest as some of the first evidence that industrial sites can be regenerated in to healthy wetlands.

According to its author, Todd Dick, its points to solution for one of the world's environmental dilemmas.

Mr Dick said steelmaking and heavy industry were traditionally established near wetlands and slag dumping was common.

"Slag material has not only been dumped in the Hunter region and across Australia, it is common in other parts of the world," Mr Dick said.

"It is a common dilemma and this research shows

***continued back page***

## *Company* Members

*A primary role of our Association is to bring together Slag Producers, Processors, Customers and Suppliers to the Slag industry. Our activities cover Technical Developments, Plant Operations and Processes, Education and Promotion. If you would like more information on the Association and how you can become involved, just complete the information section at the end of this newsletter. Current membership is as listed below.*

- *Australian Cement Ltd*
- *Australian Steel Mill Services Pty*
- *Australian National Industries (ANI Comsteel)*
- *BHP Flat Products*
- *Blue Circle Southern Cement Ltd*
- *Boral Concrete & Quarries*
- *Brambles Equipment*
- *Brambles Industrial Services (Whyalla)*
- *Cleary Bros (Bombo) P/L*
- *CSIRO*
- *CSR Readymix Group*
- *University of Wollongong – Dr Denis Montgomery*
- *Finlay Screens*
- *Gough & Gilmour*
- *Heckett Multiserv (UK)*
- *HBL (Heggies Bulkhaul Ltd)*
- *Kress Corporation*
- *Mahaffey Associates*
- *Metserv Australasia Pty Ltd*
- *Milburn New Zealand Ltd*
- *University of Newcastle – Mr Brian Heaton*
- *Nichimen Australia Limited*
- *NS Komatsu*
- *Pioneer Construction Materials*
- *Port Kembla Copper P/L*
- *Premium Tyre Service P/L*
- *Queensland Cement Ltd*
- *Roads & Traffic Authority of NSW*
- *Slag Cement Sdn Bhd, Malaysia*
- *Smorgon Steel*
- *South Coast Equipment*
- *SsangYong Cement (S) Ltd, Singapore*
- *Steel Cement Ltd*
- *Steelstone Services (Aust)*
- *Sunstate Cement Pty Ltd*
- *Sulphide Corporation P/L*
- *The Slag Reduction Company (NZ) Ltd*
- *UBE Industries Ltd*
- *Wormald Fire Systems*

## *Personal* Members

- *Anderson L*
- *Butler W B*
- *Dobson G*
- *Jones D E*
- *Maric M*
- *Marosszeky M*
- *Prosser S D*
- *Reeves C M*

## *Related* Associations

- *National Slag Association*
- *Nippon Slag Association*

# NEWS in brief

**AFTER** some 9 years as the Technical Sales Manager Roads – Bruce Fenton departed ASMS for foreign shores in March of this year. Bruce tells me he will be overseas for some 12 months or until money runs out. I would like to extend my thanks of appreciation to Bruce for his input and support of the ASA, his contribution to our University program and technical guides has been invaluable and will be will sorely missed.

Dr Ihor Hinczak joins the team at ASMS. As one of the major contributors towards the development of slag cement products over the last 30 years, Ihor has taken up the role of Technical Sales Cement with the largest slag cement processors and producers in Australia. With Ihor extensive technical and market knowledge of slag cement products, this represents a significant increase in ASMS ability to service customers information needs.

Australian Metal Recovery (AMR) Port Kembla, were recently appointed with the slag handling contract for Smorgon Steel new operation in Newcastle - ComSteel.

The slag contract should produce around 30,000 tpa of EAF slag suitable for use such in road construction works. For more information please contact Ross Johnson on (02) 4276 2549.

Major slag contractors line up for BHP Steel (Whyalla, SA). BHP is currently reviewing contract submissions for the new granulation operations. With some 250,000 tpa of blast furnace slag material generated each year, the opportunity to develop a value added market for this material is being offered. To date this slag has been air cooled and used principally in land reclamation.

**[The slag contract should produce around 30,000 tpa of EAF slag suitable for use such in road construction works.]**

*from page three*

the potential of resolution."

Mr Dick's study, funded jointly by BHP Newcastle University and Kooragang Wetland Rehabilitation Project, focused on an industrial zone near the Tourle St Bridge, which was regenerated in 1995.

Samples from two sites were compared with nearby natural wetlands between 1997 and the end of last year.

The results suggested that nutrient cycling was not dramatically influenced by the presence of slag and that planting of salt marsh and mangrove vegetation in inter tidal areas previously covered with slag heaps will not effect nutrient cycling in the estuary.

It also showed salt marsh piles established on slag heaps had established excellent lent ground cover and that mangroves grew as well on slag heaps as in natural areas.

Mr Dick found new mangroves growing on slag sites where species were transplanted.

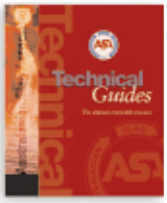
"When I initially decided to set up the trial I thought there would be a stark contrast between natural areas and rehabilitated sites."

Mr Dick pointed out that more work needed to be done on fauna to measure the overall effect.

**Slag – "the ultimate renewable mineral resource"** video has proved to be a favourite with many members. A considerable amount of new additional footage has been incorporated demonstrating the beneficial properties of slag in various large-scale projects completed in recent years. The video (15mins duration) outlines slag's historical beginnings through to the various types of slag produced in a modern production process today.

Since our last issue we have had to produced another 100 copies to meet further demand. Copies are available to members at a cost of $15.00 each, non-members $20.00 plus postage and handling. Just complete and fax back the subscription/order form indicating your requirements.

**Given the number** of high quality guides the ASA has produced, and continues to produce ("Guide to the Use of Steel Furnace Slag in Asphalt and Thin Bituminous Surfacings") together with bulletins, newsletters and general correspondence, the Education and Promotion Committee have developed a Technical Compendium for the purposes of storing these important documents and more.




The Compendiums are an invaluable reference tool for engineers, specifiers, consultants, government authorities, and various slag users. Copies are available to members at a cost of $15.00 each, non members $20.00 plus postage and handling. Please note that as amendments are made to the contents of the compendiums, registered holders will receive updates. Just complete and fax back the subscription/order form indicating your requirements.

## Subscription Form: Connections

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**Business Category** *(please tick ✓)*

❑ Producer ❑ Materials handler ❑ Industry supplier ❑ Government agency

❑ Processor ❑ Refining/value adding ❑ Specifier/Engineer ❑ Other_____

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